The Teaching of Botany in Schools.—Report of the Committee, consisting of Professor L. C. Miall (*Chairman*), Mr. Harold Wager (*Secretary*), Professor J. R. Green, Mr. A. C. Seward, Professors H. Marshall Ward, J. B. Farmer, *and* T. Johnson, Miss Lilian Clarke, *and* Dr. C. W. Kimmins.

The Conditions of Profitable Study.—In order to make the most of scientific lessons in school the teacher should have a just appreciation of the relative importance of facts; he should encourage his pupils to work for themselves, and he should adapt his teaching to their present wants. All these requirements have often been disregarded by teachers of Botany.

The Relative Importance of Facts.—In all ages teachers have been blamed for defective appreciation of the relative importance of facts. The term *pedant*, once a mere synonym of *teacher*, has come to mean a man who makes a display of vain learning, while he neglects what is practically useful. Perhaps the teachers of Botany have sinned in this way as conspicuously as teachers of any other sort. Old exercise books survive to show that in one generation instructors were content with getting the classes and orders of the Linnean system committed to memory. In a later generation they chiefly aimed at the description of a plant in correct technical language. Some manuals of Botany of old date are little more than glossaries of terms. Students of Botany have been encouraged to spend most of their time upon the characters by which the British flowering plants are distinguished from one another, the ultimate purpose being apparently a more perfect knowledge of their distribution within these islands. The scientific product of local lists has by no means justified the time and labour bestowed upon them, and their educational effect has been depressing instead of stimulating. Meanwhile the nutrition of green plants, a subject of the highest scientific interest and the very foundation of agriculture, was during many years almost ignored in schools and colleges. So late as 1870 it was very slightly treated in teaching courses, and no Englishman had made any important experiments upon it for a hundred years. It is only of late years that we have become aware that we must study our plants alive and experimentally. Scientific curiosity would surely be better occupied in discovering how plants get their food, respond to stimuli, adapt their structure to new circumstances, contend with their rivals or enemies, and propagate their race than in learning Latin names for the shapes of their leaves, or discussing which of many names proposed for a particular species was first used. It will be some guide to the formation of a sound opinion upon any teaching course in Botany to inquire whether the fact that plants are living things is ignored or put in a subordinate place.

It is a mark of the present immaturity of the Nature Knowledge movement that whenever a fresh attempt is made to stimulate the teacher, it is accompanied by a great display of dried plants, diagrams, lantern slides, models, slices of useful woods, lists of species observed, with their dates, and maps of distribution. All these are dead products, and only indicate that someone has been taking pains. Those teachers who fix their attention upon the living plant and its activities will have little need of bought appliances.

The Pupil must Work for himself.—It is probable that most men who have been productive workers in science have at length come to recognise that the best part of their learning they got for themselves. Example and guidance are thrown away upon those who do not make independent efforts ; and knowledge accumulated by a mere act of memory is feebly grasped and soon forgotten. It is not by listening to other people, nor by reading their accounts of what they have seen and done, nor by gazing at the pictures which they have drawn, that we make lasting progress in science. The pupil who has been taught thus finds himself master of mere scraps of information, too uncertain for any practical application. He has no power of enlarging knowledge, or of applying old knowledge to new cases, and it is well if he has not acquired a disinclination to carry his studies any farther.

The lecture as a mode of instruction in schools is nearly always bad. It may be a passable expedient where the lecturer meets his audience only once, and is able to suggest to them pregnant thoughts which would have never entered their minds otherwise. But even the occasional lecture is rarely stimulating, and the regular lecture is, especially to young pupils, apt to be flat. We can enliven it a little by questions, especially if the pupils feel free to question the lecturer, but that is not quite enough. Choice and responsibility are necessary conditions of interest, and these are hardly ever conceded to the pupil by any lecturer. There is a better prospect of success when the usual conditions are inverted, and when it becomes the rule for the teacher to listen to his class. Let them explain to him what they have seen and thought ; let them draw before him the structures which are under discussion. The explanations and drawings may not be so good as those of a grown man, but at least they are the expression of the thoughts of the learner.

It is practicable, as actual experience shows, to substitute for mere didactic lessons learning by personal inquiry, and it may be doubted whether any single teacher who has made the change has afterwards gone back to the lecture or the lesson book. We have no knowledge of even one such case.

A method of teaching in which every pupil is called upon to take his share has the incidental advantage that it cultivates the power of expression in the class. To be well accustomed to come forward and explain one's meaning without embarrassment, to have learnt how to describe complicated structures neatly, is no small gain to the pupil. In all but quite elementary classes the pupils may be helped, not only to practise the art of expression, but to learn how to use books aright. To search in books for the facts which are needed, and then to throw the facts into a new mould, may be excellent discipline for an advanced class. Let the teacher who is not afraid to innovate set before him as his ideal that the class is in future to do for him what he has hitherto done for the class.

In the laboratory it is a good plan to use no book at all, where a whole class works simultaneously at the same things. In biological teaching the abundance of the material, and the simple means of investigation which suffice for elementary students at least, make it possible for large classes to work at the same objects—a great advantage to both teacher and pupils. In botanical and zoological teaching, more than in other scientific courses, it is easy to adopt improved methods, such as that the teacher shall rarely give out information, but chiefly directions and questions, the class observing the object, making drawings and returning

answers ; that the laboratory work, if separated from the work of the classroom, shall always come first ; and that the practical exercises of the students shall furnish the materials upon which the class teaching is founded.

The principle of helping the pupil to work for himself will not be abandoned in the later stages of study. Honours candidates in university or college should spend at least part of their time in original work. Those who are so ill-directed as to read instead of inquiring during their whole academic course lose a great opportunity, that of carrying on a genuine research with the co-operation of a more experienced investigator. To many students the opportunity never recurs.

A Substitute for Class Lectures.—Some years ago lectures were discontinued in the Biological Department of the Yorkshire College. A class of beginners is at first questioned about their recent work in the laboratory. After a few weeks, when confidence has been gained, the students are invited to give more continuous expositions. Several topics (usually five) are written up at the beginning of the lesson, and these are handled by members of the class, called up one at a time by lot. The student whose name is drawn comes forward and treats his topic in his own way, making his own diagrams and answering questions when he has done. The topic on which he speaks is always familiar to him by work which he has already done in the laboratory. If he describes a structure it is one which he has examined and drawn for himself. Inferences and comparisons are often asked for instead of mere facts. In advanced classes more comprehensive topics are proposed, and one student may occupy the whole hour. It is hardly necessary to point out that the teacher must scrupulously avoid harsh criticism. A domineering or sarcastic manner would be fatal to the success of any such method as this.

Inquiry in the Botanical Class. (*By* A. C. Seward.)—A method which I have adopted in dealing with advanced botanical classes may prove useful in a modified form in teaching elementary Botany. After an hour's lecture the students work for two hours in the laboratory. It was during the time devoted to practical work that the following plan was followed. Instead of preparing a common syllabus for all to work through I suggested a separate piece of work to each student requiring six, eight, or more hours to complete. On the completion of each piece of work the student was asked to give a concise account of his results illustrated by blackboard sketches and by numbered sections accompanied by very brief notes. On the conclusion of the short lecture, which usually occupied from ten to twenty minutes, the other members of the class asked questions and criticised the statements made by the lecturer. The sections were afterwards examined by all the members of the class, and the preparations made in illustration of each piece of work were kept in a separate tray until the end of the course, when each student was at liberty to appropriate his slides. In an article on Botanical Teaching in University Classes, published in the 'New Phytologist,' January 1901, the above method is described at greater length, and several examples are given in illustration of the system. Since that article was written I have adopted the same plan in a course of lectures and practical work on Gymnosperms. As it was impossible to give a full account in the lectures of all the questions involved in a detailed treatment of this group of plants I omitted certain portions of the subject, and arranged that these should be dealt with by the students themselves during the practical work. As

an example of this method of encouraging students to fill in gaps left by the lecturer, one case may be quoted. X. was asked to make a comparative examination of the anatomy of the leaves of various types of Conifers; in the course of his work he was referred to literature on the subject, and his main object was to discover to what extent anatomical characters may be used in the identification of genera. The account given by X., illustrated by a selected series of his sections, rendered it unnecessary for me to refer to this subject in the lectures. The advantages of the above method over that which I had previously employed were apparent in the much keener interest taken in the laboratory work; the members of the class were in fact engaged in original research, and their attitude was that of investigators who have problems to solve which require thoughtful treatment and careful technique. They entered fully into the spirit of the work, and were stimulated to do their best, partly by the interest which they derived from the work itself and partly from the knowledge that they would be expected to give a clear account of their results to the rest of the class, who were encouraged to ask questions and offer criticisms during the short and informal lecture which the students gave on the completion of each piece of work.

The practice in speaking and presenting facts, the introduction to the methods of research, and the stimulus given by the feeling of rivalry were, I consider, the most striking advantages of the system.

The Teaching must be adapted to the Needs of the Pupil.—It is characteristic of immature minds that they soon tire. This is a reason for frequently changing the topic and for making the object-lesson the regular mode of teaching Botany in junior classes. Teachers of Botany are not so liable as teachers of chemistry or physics to make the mistake of proceeding from the general to the particular, instead of from the known to the unknown, which is a very different thing. One often recognises the inexperienced teacher by such a phrase as that he intends to begin by consideration of the principles which underlie a particular science. Continuous book and paper work is hateful to children, and their exercises in learning and thinking should be varied with handiwork, their indoor work with outdoor work.

Object-lessons in Botany.—Object-lessons are the best way of instructing children in natural history, childhood being taken to include all ages under twelve or thirteen. In this stage there should be no formal and separate sciences, though the lessons, which are at first studiously varied, may gradually become connected. Among the conditions of profitable object-lessons the following may be noted :—

(1) Every pupil should have an object to himself, or at least be able to examine the object as long and as closely as he pleases. A drawing is not to be allowed to rank as an object.

(2) Living and growing plants should be frequently observed.

(3) The living plant should not only be studied in flower, but whenever the change of season brings on a new phase of growth. Fruits, buds, and seedlings are as important as flowers.

(4) Experiment can hardly come in too early, and there is nothing else quite so stimulating. Even young children can appreciate the interest of a simple experiment, and they may be allowed to take part in it before they are able to conduct it themselves.

It is discouraging to learn from advertisements in the educational

papers what facilities are offered for scamping the object-lesson. The teacher is encouraged to buy his objects, to buy his pictures, and to buy his lessons. It is probable that the late demand for nature knowledge has greatly multiplied the number of worthless object-lessons which are given in school. Unless the teacher regularly works for himself he is not fit to show others how to work, and no good will come of inducing him to add nature knowledge to the list of subjects in which he offers instruction.

Plant-physiology in the School.—When the age of the pupils and the circumstances of the school favour the regular study of Botany we have to choose among several ways of treating the science, each of which has found zealous advocates. If the decision were left to ourselves we should give a distinct pre-eminence to the study of Plant-physiology, on the ground of its great practical importance and of its special value as discipline when studied systematically. Systematic Botany will soon be found to be a necessary adjunct if scientific precision is to be attained, and other aspects of the study will ultimately find a place in the programme, but function in connection with structure should, we think, be prominent in every part of the school course.

In preparing a scheme of instruction in plant-physiology the teacher will do well to take common objects, which will often engage the attention of his pupils in after life, which can be procured in numbers without much cost or labour, and which can be studied alive under natural conditions. The question of the sufferings of the living objects, which is of the first importance in some other branches of natural history, happily does not concern the teacher of Botany.

We can recommend nothing better for first lessons in plant-physiology than the study of seedlings of common garden plants. A course of lessons on seedlings can be so arranged as to lead the beginner to consider attentively the nutrition of a green plant, the adaptation of the plant to external circumstances, and the development of new parts. The course should also train the manual skill of the pupils. Boxes and the simpler kinds of chemical apparatus can be made in the school. The course should bring in drawing to scale, the graphical representation of experimental results, the care of garden beds, the care of water cultures, and many other practical arts. It ought also to encourage the habit of close observation, the habit of methodically comparing structures which in different plants answer the same purpose, the love of experiment, and the unwillingness (so characteristic of the scientific mind) to accept any conclusion except as the result of an independent and careful judgment. The study of seedlings will lead us to consider starch-formation in the green leaf, root-absorption, transport of food material, storage of food reserves, and other branches of the great question of the nutrition of plants. The flower and the functions of its various parts can be studied with interest and profit. Experiments on pollination and on the movements of roots, leaves, and shoots are not too difficult for pupils in school.

School Gardens. (*By* Miss Lilian J. Clarke.)—At the James Allen's Girls' School, Dulwich, we have tried for some years, instead of giving information in the Botany classes, to lead the girls to observe, to draw what they observe, to experiment, and to write accounts of their own experiments. In this we have been greatly helped by possessing a garden in which girls are allowed to own plots. The work has grown every year until now more than a hundred girls possess gardens. At first

only order-beds were made. The girls were encouraged to own order-beds and to obtain plants for them. Gradually more order-beds were added, and now the most important British orders are represented, two or more beds being sometimes allotted to one order. As far as the size of the bed and the claims of other plants permit, each girl is allowed to grow as many specimens of a particular species as she likes. The owners of order Leguminosæ generally take a great interest in growing sweet peas and ordinary peas and beans, and the owners of order Solanaceæ grow tomatoes and potatoes. Town girls are usually so ignorant of the growth of ordinary vegetables that we encourage our girls to grow many. This year there are in the gardens cabbages, Brussels sprouts, cauliflowers, turnips, peas, broad beans, scarlet runners, spinach, beet, lettuce, potatoes, parsley, parsnips, carrots, &c.

Fruits are valued as well as flowers, so most of the flowers are left to form fruits, and various methods of seed-dispersal are studied, as well as the structure of fruits. A large label is placed in front of each bed, and the name of the order, &c., is painted in white on a black background. In each bed small labels are also used; for it is the rule that to each plant, or clump of plants, must be attached a label bearing the English name. Gravelled paths run in many cases on three sides of the beds, so that many girls can work at the same time without getting in each other's way.

When studying pollination it seemed so necessary that the girls should do some work of their own that beds were arranged in which pollination experiments could be carried on. Some plants are covered with muslin in order to exclude insects, while other plants of the same species are left uncovered. Afterwards the girls find out whether fruits appear on either set. When fruits are found on both the covered and uncovered plants, the number and vigour of the fruits are compared. In some plants the stamens are cut off while the flower is in bud. These pollination experiments arouse great interest, not only in those who happen to be studying pollination, but in girls of other classes. Numbers of plants are grown for the sake of pollination by means of insects. Figwort, snapdragon, foxglove, salvia, monkshood, sweet peas, and deadnettles are found most useful, and clumps of these are grown in different parts of the garden. A class often spends the lesson time in the garden, and is divided into detachments for observation of the visits of insects.

Experiments in assimilation are carried on in other beds, and the girls find out under what conditions starch is formed in green plants. Stencils are placed on some leaves, others are covered with vaseline, and various simple experiments are made while the leaves are still on the plant. The assimilation experiment beds are owned by a few girls only, but many make experiments on leaves. In wet weather when we cannot go into the garden we find the laboratory window-boxes useful, as in them pollination and assimilation experiments can be arranged. Most of the Botany gardens are either order-beds, or beds in which pollination and assimilation experiments take place; but there are a few others, for example those in which soil experiments are made. Each year we find that something more is needed in the Botany garden, and each year something is added. Last year climbing plants received special attention, and now the girls own plants climbing by twining stems, hooks, roots, stem tendrils, leaf tendrils, or sensitive petioles.

Lately we have been specially interested in studying trees. It had been a drawback that in studying the structure of buds, methods of

branching, &c., we had no better materials than cut specimens or trees seen on excursions. This year there has been planted in the garden a specimen of every common English tree not already possessed by us, and we hope that in future the girls will draw different stages of development of the buds of oak, beech, ash, sycamore, maple, willow, &c., while still on the trees.

Two years ago we thought of making a pond for water plants, but this was judged inadvisable, and instead of a pond in the garden a tank is provided in our new botanical laboratory.

As gardening is not a regular branch of the school work, and no school time is allowed for it, the work must be voluntary ; but there are many applications for Botany gardens, and great enthusiasm is shown. The school is a day-school, so digging, planting, weeding, and watering are done in the dinner hour, or in the hour immediately following afternoon school. The practical work appeals to many who would not be interested in books, and in several cases the gardens have been the means of arousing a girl's interest in plant life. In fact we have found the out-of-door work of such value that we hope to extend it, and allow more and more of the school work in Botany to depend on the observations and experiments made by the girls in their gardens.

Excursions.—The school excursion is highly valued as a means of stimulating observation in the field, but we are inclined to think that for want of attention to details its benefits are often imperfectly attained. Excursions are sometimes wholly unprofitable. The leader stops now and then to pick a flower, names it, mentions, perhaps, some curious feature which it exhibits, pops it into his vasculum, and walks on. Most of the party are not within hearing : they have no part assigned to them, and they bring back nothing more valuable than a few dying flowers, with a fleeting memory of some of their names. On a botanical excursion we ought to remark not only flowers and the peculiarities which distinguish them, but the ripening of fruits, the dispersal of seeds, and defences against scorching sun or winter cold. It is only by visiting the same plant at different seasons of the year that we become acquainted with what may be called its biography. To insure the active co-operation of all the members of the class, we have found it useful to distribute a cyclostyled programme, describing, but not as a rule naming, things which are to be looked for.

Example : A Moorland Walk.

1. Find several plants with rolled leaves.

2. Find a plant whose leaves are converted into spines. Look out for seedlings of the same plant.

3. Bring leaves of three moorland ferns. Can you find one which has two distinct kinds of leaves ?

4. Find a moorland grass with fine wiry leaves. Can you find more than one answering to this description ?

5. Find a moss which is very plentiful in swampy parts of the moor. Find another which is plentiful in dry places, and occurs in two distinct forms.

6. There is a low plant on the moor which is now in flower. It grows in large patches, and from some of these patches we kick up dust with our feet, while other patches yield no dust. Bring specimens of each sort.

7. How many years old is the biggest stem of ling which you can find?

The objects brought can be named and discussed at convenient halting-places. The school excursion should have a definite aim lest it degenerate into the raid upon wild flowers. It is a good plan to follow it up within a very few days by a lesson on the same objects.

Collecting.—We have a poor opinion of drying plants as an incentive to the study of Botany. The dried plant is an inadequate substitute for the living and growing plant, and finds its principal use in the authentication of botanical discoveries made in distant lands. The habit of collecting plants for the herbarium may be hostile to close study of the environment, and confirm the pernicious belief that the thing of chief importance is to be able to name a plant as soon as you see it. One lamentable result of the rapacity of collectors is that our native flora has become sensibly impoverished of late years. There is little gain to science by way of compensation. Amateur herbarium botanists have not, in our own time and country, done much to solve important questions of any kind, and they often propagate the misleading notion that rare species are better worth attention than common ones. The rarity of a plant is a reason, not for gathering a flower and drying it, but for letting it alone, unless, indeed, you can accomplish some important and unselfish purpose only by its sacrifice.

The museum, like the herbarium, may easily be perverted from its proper function and made a means of oppressing the intelligence of young persons. A vast multiplicity of objects bewilders instead of stimulating the observing faculty. We do not mean for a moment to disparage museums. They are indispensable to the special student, who, as science advances, demands that the museum shall become ever more complete and more rigidly systematic. But the wants of the specialist and of the schoolboy are so dissimilar that they cannot be met by the same collection. A school will be fortunate if it possesses a few striking objects of nature or art, such as a Roman altar, two or three Greek coins, a fine ichthyosaur, a mammoth's tusk, and the like; but long series of woods, seeds, moths, fossils, and minerals are simply dispiriting to the beginner. Schoolboys can do nothing with them except make inferior copies of the same kind. It ought to be needless to remark that the needs and also the powers of the schoolboy are altogether unlike those of the adult specialist. The specialist attends to few things and seeks to master those in every detail. Precise language and minutely accurate knowledge are indispensable to him. He has chosen his walk of life, and knows that his strength and usefulness largely depend upon his power of concentration. The schoolboy is untrained, and his future vocation often unknown. Now is the time for him to learn the scope of various sciences, literatures, and histories. But the workshop routine of the professed botanist may do the schoolboy harm instead of good.

In our opinion both herbaria and museums are indispensable to scientific progress. They have their uses even to children, and many naturalists have begun by collecting. But there are things more advantageous and more appropriate to the first stage of botanical study than the accumulation of a pile of wild flowers, dried and named. School collections, illustrating the dispersal of fruits and seeds, the shapes of leaves in connection with bud folding and exposure of the largest possible surface to light, resistance to drought or cold, &c., may be made to gratify

the collecting instinct in a harmless way, and at the same time to promote definite inquiries. It is the mechanical habit of collecting for selfish ends, and without any scientific purpose, that we wish to discourage.

Systematic Botany in the School.—The time to introduce systematic Botany into the school course is the time when the need for it is felt. Good teaching will soon make it desirable that the class should be able to recognise such families as grasses and leguminous plants. The families, introduced to notice one by one and illustrated by fresh examples, soon become interesting, and even children delight in the power to run down the easier flowers. Simple descriptions of the families of flowering plants, in which the Latin words are cut down to a minimum, will greatly promote the attractiveness and intelligibility of early lessons in classification. We have no high opinion of the description in technical language, once so strongly recommended, nor of the filling up of schedules. All this is apt to divert attention from things of greater consequence, and to stupefy the docile, while it alienates pupils of active disposition. One independent observation, one carefully conducted experiment, is worth sheaves of schedules.

The Teacher to devise his own Course.—It is natural that the teacher should seek the help of books in preparing his lessons on plants. Such help only becomes mischievous when he becomes dependent upon others alike for information and method. Servile reproduction of another man's lessons is a proof of incompetence. Not only do we maintain that the language and the selection of facts should be the teacher's own, but we would have him plan his own course of work. The unenterprising teacher may look upon the detailed syllabus as a safeguard, but to a teacher of any spirit it is intolerable tyranny. The low condition of elementary science in our schools is largely due to unwise examining. The detailed syllabus, the worship of technical language, the authoritative enunciation of general principles to pupils who have no knowledge of concrete facts, and the practice—still widespread—of endeavouring to learn a science by heart are largely due to the influence of public examinations. Liberty for the teacher is essential to progress on good lines. How to reconcile liberty with tests of efficiency is a difficult but by no means an insoluble problem.

Microscopes in School Work.—The appliances required for junior classes in Botany are few and simple. Much may be done with common knives, needles, and simple lenses. When the dissection of plants becomes a regular occupation, an inexpensive dissecting microscope such as that sold by Leitz of Wetzlar for 8*s.* will fulfil many requirements. Still simpler home-made stands will answer the purpose. It is good for any teacher who has a mechanical turn to devise his own microscope. To make them really useful there should be at least one to every pair of pupils. The compound microscope should never appear in junior classes, and we are inclined to think that it will be best to reserve it for the highest form in a secondary school.

Histological details and a knowledge of microscopic plants are often expected of pupils who have never had the use of a microscope. This inevitably leads to unreal teaching.

Other Teaching Appliances.—Diagrams and lantern slides are often made too much of in school work. They should be mere accessories which have their uses in particular cases. A good teacher will not depend upon them, and will usually prefer the drawing made in class. To make the most of simple means is an education in itself.

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